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Systematics of Early Cambrian Paleomagnetic Directions from the Northern and Eastern Regions of the Siberian Platform and the Problem of an Anomalous Geomagnetic Field in the Time Vicinity of the Proterozoic–Phanerozoic Boundary

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Abstract—Representative paleomagnetic collections of Lower Cambrian rocks from the northern and eastern regions of the Siberian platform are studied. New evidence demonstrating the anomalous character of the paleomagnetic record in these rocks is obtained. These data confidently support the hypothesis (Pavlov et al., 2004) that in the substantial part of the Lower Cambrian section of the Siberian platform there are two stable high-temperature magnetization components having significantly different directions, each of which is eligible for being a primary component that was formed, at the latest, in the Early Cambrian. The analysis of the world's paleomagnetic data for this interval of the geological history shows that the peculiarities observed in Siberia in the paleomagnetic record for the Precambrian–Phanerozoic boundary are global, inconsistent with the traditional notion of a paleomagnetic record as reflecting the predominant axial dipole component of the geomagnetic field, and necessitates the assumption that the geomagnetic field at the Proterozoic–Phanerozoic boundary (Ediacaran–Lower Cambrian) substantially differed from the field of most of the other geological epochs. In order to explain the observed paleomagnetic record, we propose a hypothesis suggesting that the geomagnetic field at the Precambrian–Cambrian boundary had an anomalous character. This field was characterized by the presence of two alternating quasi-stable generation regimes. According to our hypothesis, the magnetic field at the Precambrian–Cambrian boundary can be described by the alternation of long periods dominated by an axial, mainly monopolar dipole field and relatively short epochs, lasting a few hundred kA, with the prevalence of the near-equatorial or midlatitude dipole. The proposed hypothesis agrees with the data obtained from studies of the transitional fields of Paleozoic reversals (Khramov and Iosifidi, 2012) and with the results of geodynamo numerical simulations (Aubert and Wicht, 2004; Glatzmayer and Olson, 2005; Gissinger et al., 2012).

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INTRODUCTION

It is well known (e.g., (Merril et al., 1996)) that the Earth's magnetic field during the geological history could exist in two states:

(1) a stable state (of normal or reversed polarity), with a predominant dipole geometry and wide spectrum of the lengths of geomagnetic polarity intervals ranging from hundreds of ka to dozens of Ma;

(2) a transitional (reversal) state with the complex geometry of the field and a duration ranging from a few hundred years to the first few kA.

The recent studies (Pavlov et al., 2004; Abrajevitch and Van de Voo, 2010; Biggin et al., 2012; Bazhenov et al., 2016; Halls, 2015; Gallet and Pavlov, 2016; etc.) indicate that in the history of the Earth there probably were sufficiently long periods (on the order of a few Ma and longer) when the state of the Earth's magnetic field differed from the two regimes noted above. The main distinctive feature of this new fundamental state was hyperactivity, i.e., extreme variability of the main parameters of the field (the direction, intensity, amplitude of secular variation, etc.) and/or significant deviation from the axial dipole geometry.